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ADAPTATIONS TO AQUATIC, ARBOREAL, FOS- SORIAL AND CURSORIAL HABITS IN MAMMALS.

II. ARBOREAL ADAPTATIONS.

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IN THE struggle for existence it is apparent that single forms and whole groups of forms would independently become modified to a life off the ground. Very often only by such an adaptation could small defenseless animals save themselves from the attacks of larger and speedier carnivores. In addition, there is the question of food. The larger animals to whom the bulk of terrestrial food naturally goes are virtually absent from the trees. We accordingly find a multitude of animals that have made this region their abode where, freed from their enemies and with an abundance of food they have prospered.

PARTIAL LIST OF ARBOREAL MAMMALS.

Order MARSUPIALIA.

Family Didelphyidæ (all except Chironectes).

“ Phalangeridæ

“ Macropodidæ (Dendrolagus only).

“ Dasyuridæ (Dasyurus and Phascologale only).

Order EDENTATA.

Family Bradypodidæ, Myrmecophagidæ (only Tamandua and Cycloturus).

Order UNGULATA.

Sub-order Hyracoidea (Dendrohyrax).

Order CARNIVORA.

Family Felidæ (many partly, the Jaguar alone truly arboreal).

“ Viverridæ (the Fossa, Viverra and Arctictis).

“ Procyonidæ (Procyon, Kinkajou, Bassariscus, Nasua and Bassaricyon).

Family Mustelidæ (the Martens and Helectis).

Family Ursidæ (the Brown Bear).

Order RODENTIA.

Family Anomaluridæ.

“ Sciuridæ (Sciurius).

“ Lophiomyidæ.

“ Myoxidæ.

“ Hystricidæ (only the American sub-family Synetherinæ).

Order INSECTIVORA.

Family Tupaiidæ.

“ Erinaceidæ (Gymnura only).

“ Galeopithecidæ.

Order CHEIROPTERA.

Order PRIMATES.

(All except Homo and the Baboons.)

It will be observed from this list that with the exception of the Monotremata, the Cetacea and the Sirenia all the mammalian orders have arboreal representatives. Thus of the six

existing marsupial families two are completely arboreal while arboreal forms are found in one or more representatives of each of the remaining families. Among those forms that are not arboreal there still persists a considerable number of vestigial structures and conditions in the pes all pointing unmistakably to a previous arboreal life. In like manner among the edentate sloths, many of the smaller Carnivora, Rodentia and Insectivora and finally the Cheiroptera and in large part the primates have become arboreal.

This adaptation however is probably a secondary one, acquired independently by the different orders. We should therefore expect diverse forms of the adaptation to exist. Here we shall distinguish the following main types :

I. *Partially arboreal*. These are still capable of terrestrial life. Here belong the majority of the carnivores, insectivores, and rodents, and Dendrohyrax.

II. *Strictly arboreal*. This contains the remaining forms and is divisible into three sub-groups.

(a) Modified for running on branches.—Arboreal marsupials and lemurs.

(b) Modified for suspension from branches.—Sloths and bats.

(c) Modified for swinging by fore limbs ; hind limbs on the marsupial type.—Remaining arboreal primates.

It is clear that this classification expresses corresponding differences in foot structure. In the first group the pes is little different from the typical terrestrial running foot. The phalanges have, as in the raccoons, become much elongated and the soles are often naked. In some cases a distinct plantigrady has replaced the previous digitigrady.

It is in the second group that the greatest modification has occurred. In the first subdivision (a) the foot has become an almost perfect grasping organ ; the hallux being opposable ; the second and third digits have reduced and united ; the fourth toe is greatly elongated. There is also a distinct regression of the claws ; for as the foot becomes more and more prehensile in structure the nail is no longer indispensable and is lost (Dollo).

In the second sub-division (b) of the second group, the manus and pes have become much elongated and centrally strengthened

and the nails have been modified into hooks by means of which the body is kept in suspension. The number of digits is reduced to two in *Cholæpus* and three in *Bradypus*. The carpal and tarsal elements are laterally compressed and there is some anastomosis. This forms a more compact centre of resistance, while the proximal bones develop a more or less complete ball and socket joint in connection with the distal ends of the radius and tibia, to permit a more perfect rotation.

In the last sub-division (c) both the manus and pes have become grasping organs. The hallux or pollex, or both, are generally opposable. Many modifications occur in the pes very similar to those already described for the marsupials.

But in spite of these differences in main type there are developed certain important characters which distinguish arboreal forms as a group from related terrestrial and aquatic types. These like responses to the same conditions are to be observed in what are otherwise most diverse forms. These characters are the following :

1. The tail is often prehensile and, as in some of the *Cebidæ*, naked at the tip being a sort of fifth arm with which the animal can move from branch to branch. Frequently correlated with this adaptation is the loss of the thumb.

2. Ectodermal spines are often developed. These may occur on the root of the tail as in the *Anomaluridæ*, on the shoulder or on the feet as in *Gymnura* and some of the *Anthropoidea*. In all these cases the spines are climbing organs.

3. The limbs are much elongated. This elongation may occur in different segments in different forms. In the swinging apes, it is the fore-arm rather than the hand which is elongated. In the tree-sloths all the limb segments except the compressed carpalia and tarsalia and proximal phalanges are lengthened, the very long remaining phalanges and the claws forming a hook for suspension. In other forms the tarsals are greatly lengthened as in *Tarsius*, *Galago* and other lemurs. These elongations are obviously connected with the climbing and leaping habits of these forms.

4. The hallux or pollex, or both, are generally opposable. This gives the hand or foot a stronger hold on the branches and

is perhaps the most important element in the arboreal limb. It disappears however when the animal moves in suspension as in the sloths.

5. The clavicle and scapula are well developed. These give strength to the fore extremities and thus increase the climbing power. It is interesting to observe that, as occurs in the *Hystrioidæ*, the clavicles will be developed in one arboreal form while a terrestrial member of the same family will have vestigial clavicles or none at all. Together these two bones strengthen the pectoral arch "in the transverse direction; that is, against lateral strains of pulling and pushing, which came almost entirely from the use of the anterior limbs (Cope)."

6. The ilium is broadened in some forms, particularly in *Anthropoidea* and the tree sloths. This adaptation is for the support of the viscera. In the edentates the pubis is directed posteriorly.

7. In arboreal forms the ribs and chest are powerfully developed as compared with the conditions in their non-arboreal relatives.

8. The number of the dorsolumbar vertebræ is often increased. It is in the tree sloths among the *Edentata* that the greatest elongation occurs. In the two-toed *Choloepus* the number is twenty-seven, and twenty-five in the species *didactylus* and *hoffmanni* respectively, while the number typical for the other forms of the order is about nineteen. In the three-toed *Bradypus* the number is the typical nineteen. Curiously enough it is the cervical region which is here elongated there being nine cervical vertebræ instead of six or seven as in the remaining *Edentata*. While one form has specialized itself to firm suspension the other has more or less sacrificed this character for a perhaps more valuable one — the mobile neck. Among the *Rodentia* where the typical number of dorsolumbars is nineteen, *Capromys* which is arboreal possesses twenty-three. *Hyrax* and *Dendrohyrax* have thirty and twenty-eight respectively; fully six more than that prevailing among the terrestrial ungulates.

If inverse evidence can be of any value, it is known that in the human species, ancestrally adapted to arboreal life, there is a tendency toward the shortening of the back; there being gen-

erally, one less vertebra in man than in the still arboreal apes. On the other hand among the marsupials where typically arboreal forms prevail the number is constant for the group — nineteen. This may be due to the fact as Dollo has shown that the terrestrial forms have but very lately modified themselves to this mode of life — the whole group of marsupials having been at one time arboreal. In like manner the number in the carnivores is constant (twenty). In this group the arboreal forms have but lately diverged from their terrestrial relatives. In the Insectivora there is also no difference of any significance.

Among isolated adaptations may be mentioned the modified feet of Hyrax and Dendrohyrax. As described by Dobson these animals are enabled to climb perpendicular walls and trees without the use of claws; nor is there an opposable hallux or pollex. The thickly padded tuberculated soles are drawn up by certain flexor muscles thus leaving a vacuum by means of which the animal retains its hold. In the Cercolabidæ there are in addition to other arboreal characters such as spines, tubercles on the soles which may serve as in Hyrax.

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